Scenarios for low carbon corn production

Modeled results for 35 farms in the southwest Minnesota feedstock shed for a corn-based biorefinery

By:

John J. Sheehan, PhD
Institute on the Environment
University of Minnesota

Jeffrey Kent
Kendrick Killian
Keith Paustian, PhD
Stephen Williams
Natural Resources Ecology Laboratory
Colorado State University

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Executive summary

In 2011, researchers at the University of Minnesota collected and analyzed detailed survey data from over 40 farms that had been suppliers to an ethanol biorefinery in Luverne, MN. That study clearly demonstrated the importance of characterizing individual farm performance, which varied tremendously, based on specific farm management practices.

In this follow-on study, we conduct "cyber experiments" on 35 of these farms to assess the effect of key management strategies on the net carbon footprint of the corn grain produced on these farms. Included in the net carbon footprint are modeled estimates for soil carbon and soil nitrogen emissions (expressed as grams of CO2 equivalents per kilogram of grain) and life cycle greenhouse gas emissions associated with major inputs for each farm (fertilizer, chemicals, fuel, etc.).

Our results illustrate the critical importance of tilling practice and nitrogen application rate in reducing the carbon footprint of the grain harvested and delivered to the biorefinery (see Figure 1).

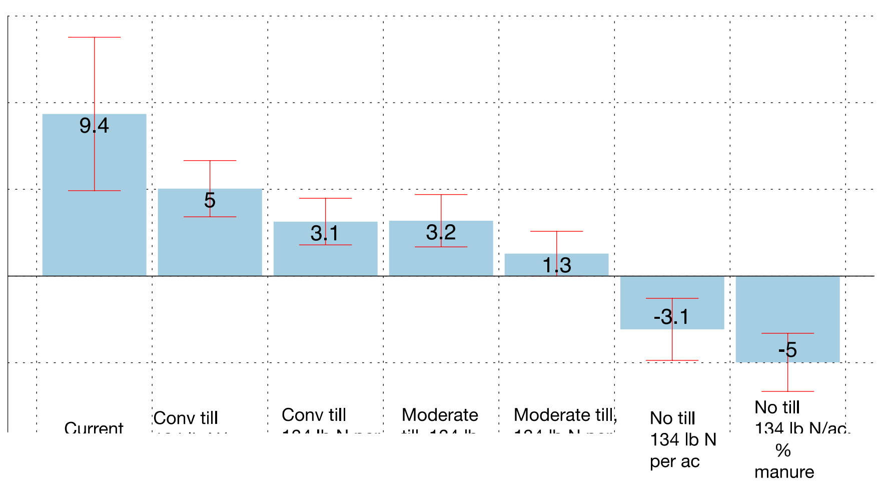

Figure 1. Average net carbon footprints of surveyed farms as a function of tillage[1], nitrogen usage rate and animal manure utilization. Error bars represent one standard deviation from the mean value.

Supplying half of the fertilizer in the form of animal manure has significant benefits as well, but the major benefit appears to be enhanced soil carbon sequestration associated with the use of no till practices.

The current mix of practices on the surveyed farms results in a farm-averaged net carbon footprint of 9.4 lbs. of CO2 per bushel of grain harvested. We found that simply backing off on nitrogen application rate from the current average level of 200 lbs. per acre to 134 lbs. N per acre could reduce the net carbon footprint by 46% (from 9.4 to 5.04 lbs. CO2 per bushel) with no effect on yield—even under conditions of conventional tillage. Use of manure to supply half of the farm's fertilizer demand reduces the average net carbon footprint of these farms by 66% to 3.14 lbs. CO2eq per bushel of grain.

More importantly, we found that adoption of no till practices could turn these farms from net carbon sources to net carbon sinks. While we model standard no till operations, it is more likely that these farmers would use something akin to strip till practices in which a narrow strip of residue is cleared from where the seeds are planted. From a carbon management perspective, this type of tillage has the same effect on carbon accumulation as the no till practice we modeled. Under no till operation and under the reduced nitrogen application rate of 134 lbs. N per acre, these farms provide a net reduction of 3.13 lbs. of CO2eq per bushel, and reach a net reduction of 5 lbs. of CO2eq per bushel when half of the fertilizer demand is met with animal manure.

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[1] Model results include conventional approaches to no till operations, though (due to climate conditions in Minnesota) it is likely that farmers would use a functionally equivalent form of no till known as strip till which promotes faster plant establishment.

Finally, a preliminary look at the potential impact of collecting and using residue (corn stover) suggests that: 1) it is possible to remove as much as 50% of the stover without causing a loss in soil organic matter, and 2) if the stover is used as an energy source to replace natural gas, its fossil carbon savings per kg of harvested grain are huge. Collection and use of stover for heat and/or power generation (either in a biorefinery or other applications) is not, however, widely practiced commercially.

This preliminary analysis captures only a small fraction of the total number of scenarios that have been modeled to date. The purpose of this report is establish the magnitude of the impact associated with farm management changes, and, based on that impact, to decide whether more comprehensive optimization of farm operations is worth pursuing. We conclude that the benefits of better farm management in the form of significantly reduced carbon footprints are potentially very high, and recommend that a more comprehensive assessment be carried out.